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Inhaltsverzeichnis – Band II

AUTOMATION I

AUTOMATION II

ELECTRIC MOTORS

DRIVING RESISTANCE

COMPONENTS I

COMPONENTS II

VEHICLE DYNAMICS II

Inhaltsverzeichnis – Band I

KI - Deep Learning II

Combustion Engines: Modeling

E/E Architecture

Charging

Battery II

Battery I

Reports from FVV Projects

VEHICLE TECHNOLOGY

Check for updates

Individualization of the drive types with the overall vehicle concept for small commercial vehicles

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Abstract. The emission-free drive type for small commercial vehicles for inner-city supply must remain individualized and technically combined in the overall vehicle and infrastructure concept.

Keywords: Commercial vehicles · Drive concept · Inner-city delivery

1 Introduction

1.1 Principle

Small commercial vehicles for inner-city delivery must be increasingly individualized in terms of drive type and vehicle concept. The prerequisite is climate neutrality or zero emissions during operation and the vehicle must meet the logistical requirements and be adapted to the possible infrastructure. The discussion is currently mainly on vehicles in the CEP area, but a large number of requirements for vehicle, drive and body have to be solved for inner-city development. In the future, vehicle concepts will have to be driven emission-free, and auxiliary units will not require negligible energies. Tail lifts, tippers, refrigeration units, body heating are just a few of the energy consumers. Therefore, the overall vehicle design must be developed in such a way that the individualization of a commercial vehicle for last-mile delivery to demand and infrastructure can also be produced economically in small series, even in one-off production. All in all, there are very high quantities, as the craftsman and service vehicles must also be included.

1.2 Technology

Contrary to the efforts in series production to standardize vehicle concepts for specific logistical requirements, the majority of small inner-city delivery vehicles will also have to be offered individually in the future. We currently have commercial vehicles that are almost exclusively equipped with combustion engines and are operated with diesel fuel.

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The vehicles consist either of a cab for 2 or 3 people and a cargo space as a box wagon van or as a chassis with a separate body that is individually adapted to the user's needs. A high degree of individualization in the area of the cargo space or the body is state of the art today. New forms of propulsion such as battery-powered vehicles are not being developed from scratch, but existing vehicle concepts are being converted.

1.3 Requirement

In the current designs for small commercial vehicles for inner-city delivery, the commercial vehicle with a total weight of up to 3.5 t is in use. As long as drivers with the old driving licence class 3 (C) are still active in the labour market for reasons of age, the 7.5 t GG commercial vehicle still has a significant share of the vehicle fleet in Germany.

The requirements for small commercial vehicles for inner-city delivery are very diverse. Essentially, factors such as driving licence class, resulting in a maximum of 3.5 t GG, cargo space volume, payload, no speed limit (80 km/h), no tachograph obligation and purchase price are today's requirement profiles that a small commercial vehicle must meet.

Range, infrastructure for refuelling, external and complete vehicle mass points are not essential requirements. For a targeted development of commercial vehicle concepts, reliable framework conditions from the political side are primarily required. Secure legal positions, such as driver's license classification, regulations for the supply of inner cities.

Funding possibilities, use of the various energies, dimensional and weight specifications of commercial vehicles, StVZO regulations and much more.m., must be reliably specified in order to obtain planning security for vehicle concepts.

Aktuelles Nutzfahrzeug für last mile/Quelle Erhardt

2 Overall Concepts

2.1 Vehicule

In the future, overall vehicle concepts will have to be developed on many factors. Several influences on the vehicle concept will be implemented and must be implemented, and the infrastructure will play a very important role. The infrastructure will have an impact on the type of drive, which is why current studies cannot be implemented, as no final solution of general infrastructures can be recognized.

Concepts for the vehicle must therefore be individually designed and constructed. It must be possible to provide economic production in small series in order to be able to react more quickly to demands and changes. In the first stage, transitional solutions must be developed, as in the medium term the vehicles will still be moved largely manually by a driver, but in the long term the vehicles will perform their service autonomously. In future development, drive technology must increasingly adapt to the logistical requirements of the vehicle concept and infrastructure.

2.2 Drive

The existing drive type can be defined for the use of combustion engines, in commercial vehicles diesel. The infrastructure is a nationwide network of petrol stations over which a user neither has to worry nor be included in his logistical considerations. From today's perspective, new drive types will have to access the following resources.

Hybrid	Electricity/E fuels	Battery E Motor/Tank Combustion Engine
Pure Eletric power	Electricity/battery	Battery. Electric motor
Gas	CNG oder LNG	Tank combustion engine
Hydrogen	Hydrogen	Fuel Cell Battery –Electric Motor
Combustion engine	E fuels	Tank combustion engine

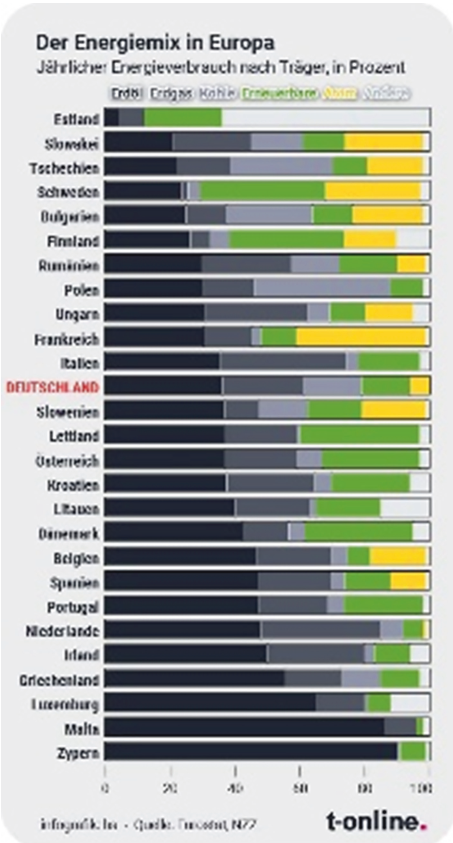
While in the passenger car the pure Electric vehicle is prioritized and promoted by the political side, in the commercial vehicle considerably more influences and requirements must be taken into account and asserted.Actually, this also applies to commercially used cars, but this is currently not significantly taken into account.

In all technical solutions, safety, e.g. crash, fire, etc. must be given a high degree of importance, weights play a role, the prices and price development of the energy, the production costs and the CO2 balance, the availability of the raw materials required for all alternative energies must be meaningfully checked and clarified in the run-up.

2.3 Infrastructure

The existing or the infrastructure to be built provides the decisive basis for drive technology in small commercial vehicles, but also in heavy commercial vehicles, which vehicle concepts can be used. A fleet of vehicles that has its own parking space with a loading structure can supply the city centre with pure E transporters. Charging overnight or at times when the vehicle is not in use and with a battery volume that sufficiently fulfills the day tour is the right solution. However, the infrastructure is not nearly sufficient when it comes to charging stations, gas filling stations, hydrogen filling stations or e.fuels. However, the last three energies mentioned could be integrated into the existing filling station network at relatively short notice.

The refuelling time also corresponds to today's diesel or petrol refuelling time. With the e-charging station infrastructure, there are neither sufficient columns nor can small trucks (vans use the existing network for reasons of space. The parking spaces reserved for the charging stations are designed for cars, therefore too small for vans. In distribution mode, a charging time of 30 to 60 min to be set today, depending on the provision of the kW, is also not possible.



Quelle internet Plattform t-online

3 Alternative Solutions

3.1 Driver-Operated Concepts

We have to think and prepare for alternative vehicle concepts and the associated drive technology in several steps, but at least in two steps. First of all, we will still have the driver-driven commercial vehicle and will have to develop an overall vehicle concept with the alternative drives, but that autonomous driving is already a goal. In this concept, existing vehicles will form the basis and only the drive technology will be replaced. The challenge, however, will be to handle the ancillary equipment, such as refrigeration units, tail lifts, tippers, loader cranes, load compartment heating and much more.m. in terms of energy technology. Certainly, larger batteries can be used, but means more empty weight, higher price and longer charging time. Today, either the battery is charged by alternator while driving or the motor is used to operate a loading crane or an aerial work platform via auxiliary drive.

3.2 Autonomous Vehicules

With autonomous commercial vehicles, completely new possibilities arise for the development of new overall concepts. Driver's seat is omitted, whether a person will still be required depends on the logistical model. The question of how to load and unload, how the distribution from the vehicle takes place, must be clarified. But even in this technical case, variables must be possible.

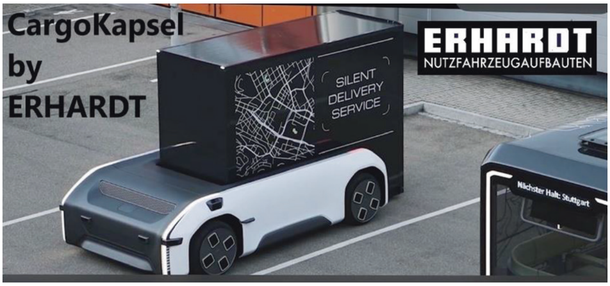
Two basic logistics solutions can be used, the one solution is strongly based on today's models, vans as box wagon van or with a separate body, at least one person travels with the van to do the service on site, the second alternative is a transport container that can be built and used for all purposes, e.g. food area, refrigerated, unrefrigerated, non-food area, as a transport container or packing station for Self-service, garbage collection, passenger transport, and a variety more.

These containers are transported by autonomous drive boards, which are purely electrical and driven by wheel hub motors. If it is still possible to technically develop basic platforms for both concepts, in which 2 drive types can be optionally installed, a high degree of variability is guaranteed. This means the individualization of drive technology in the small truck of the future.

3.3 Proposed Solutions

In the case of a commercial vehicle, a secure range must first and foremost be ensured. Infrastructures must be securely available and loading or refuelling processes must also be calculable. In contrast to the passenger car, the commercial vehicle is a vehicle that is purchased and used according to TCO values. Here, in addition to the acquisition costs, the maintenance costs play a much higher factor.

On average, the acquisition costs amount to about 20 % and the maintenance costs about 80 % of the total costs of a commercial vehicle during its lifetime. The service life of a commercial vehicle can be assumed to be about 8 years, which is not yet certain for the new types of drive that we know today. Requirement as listed in item 1.3. must first be reliably demanded.



Quelle DLR Projekt U shift, Cargokapsel von Erhardt

In our list, we have shown 5 variants of the drive technologies. Clear guidelines must be laid down from the political side so that both manufacturers and users have planning security for a very long period of time. In today's considerations, not only technical solutions of today must be considered, since we should be in a very dynamic development process and accelerate the transformation rather than slow it down.

The alternative of pure electric drive will certainly play the greatest importance in future mobility and can be implemented relatively quickly. The charging infrastructure, which must ensure the safe use of commercial vehicles, is also required.

For battery operation, the housing and isolation of the battery packages can still be a trend-setting equipment, so that the batteries can be air-conditioned and get the optimal efficiency. A significantly higher wealth security can thus be achieved. In addition, replaceable batteries, e.g. in drawers, can be installed, which enable a range extension at short notice.

The alternative **gas-powered drives with CNG or LNG** are a way to drive immediately emission-free if the production of the gas is produced accordingly emissions-free. An infrastructure is currently being set up that is essentially aimed at commercial vehicles.

The alternative **hydrogen fuel cell** is to be classified as important at the level of the purely electrically powered vehicle. Infrastructure can be set up short-term, ranges are guaranteed, refuelling time is equivalent to the burner, energy can be optimally stored and stored and in the technical design, the system can be installed in former combustion engine designs.

The alternative **hybrid, consisting of combustion engine and battery-powered drive,** can be a possibility if the combustion engine is operated with e Fuels. A solution that can be implemented at short notice, the infrastructure can also be set up at short notice.

The alternative of operating **combustion engines with E Fuels** is the fastest solution to operate a vehicle without any emissions. The infrastructure can also be built up at very short notice, a very interesting solution when it comes to immediate emission freedom.

Erhardt Model, selbsttragende Cargobox mit Akku-Einhausung und Schubladenfach

Isogehäuse/Schublade für Akku-Packages im Nutzfahrzeug-Unterbau integriert

Isogehäuse/Schublade für Akku-Packages im Nutzfahrzeug-Unterbau integriert

In conclusion, we already have technical solutions that make our vehicles emission-free. For the coming autonomous vehicle generations, there will still be many possibilities for how we can equip the overall concepts with emission-free drives. It is important to use this opportunity and to sound out the possibilities today and to develop the final solutions as quickly as possible.

In all considerations and solutions, it is important to define the framework conditions in order to be able to work reliably with the guidelines. With an individualization for the overall vehicle concepts, there is a great opportunity for the KMU (small and little -companies) to participate significantly in the transformation process through network constructions.

Quellen:

1. DLR Projekt U Shift
2. T-online Veröffentlichung Energien
3. Erhardt Model Förderprojekt ECB
4. Erhardt 1:1 Iso-Akku-Gehäuse

Blockchain-based Test Management in Full Vehicle Testing

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Abstract. As an important extension and modern methodology to fully digitize test management in full vehicle testing, we present the possible advantages of using modern blockchain technology and contrast classical methods. In doing so, we present some of the various requirements for the stakeholders and how these challenges can be met with the help of the new properties of distributed ledgers. This technology has all the properties of a decentralized database and can thus be used as a neutral storage medium, which would ensure the highest level of manipulation resistance and access security. The integration of such a solution requires a fully digitized, modern test environment that can be developed through consistent process digitization. The following four core characteristics of such a system would be:

- Machine and human readable, standardized tests and assignment to specifications
- Objective and subjective evaluation measures
- Storage of results in databases (e.g. the blockchain), comprehensive reporting, traceability of measurements
- Communication of final results and testing metadata in the blockchain

Keywords: Blockchain · IOTA · Test management

1 Test Management Stakeholders

Recent articles refer to the role of blockchain in the engineering and manufacturing process (see [1] and references therein). We take a closer look on the testing process and how it can be related to blockchain technology.

Within the development process of integrating technical parts or subsystems such as steering or braking systems into the full vehicle, many stakeholders are involved. Each of them has different main interests, sometimes overlapping, but still various interests, and therefore different approaches exist in their realm of responsibility. The OEM wants to verify the full specifications of each functional part and functional group in simulations, on test benches and finally in the full vehicle integration test. The main objective of those extensive development process is to avoid expensive late rework and redesign cycles which would involve

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extra testing. The reason for this is mainly due to legal responsibilities with respect to the final product. Tier 1 and suppliers, want to meet the specifications to avoid expensive extra demands and to fulfill their responsibility with respect to the specifications. Next there are soft- and hardware suppliers as test enablers, who seek to leverage the testing processes and provide with facilities and tools. Last but not least, there are external auditors: they want to access relevant and guaranteed tamper-free evaluations and measurement data. In general there is a multi-stakeholder situation, in which it is not feasible to implement a centralized solution where all interests are equally taken into account. In fact, even if only one of the parties tries to implement a solution, that would be disadvantageous to a fully decentralized system in terms of efficiency, transparency and trustworthiness. This claim will be explained in detail. It is worth mentioning that testing enablers may contribute in a crucial way to the testing process. The reason for that lies simply in the role of the software provider: they have their hands on data formats, semantics and communication interfaces.

2 The Cooperative Test Management Alongside the Development Path

2.1 Reasons for a Cooperative Test Management

The main reason why testing should be subject to joint cooperative efforts is the increased efficiency. The testing cost can be reduced, if the activities in this area will be created to be consistent throughout the development process. This means to introduce consistent data formats, interfaces and ensuring clear responsibilities. It is difficult to estimate the full potential of cost reduction, but it is estimated minimum 10 to 30 %. This potential can be unleashed by removing overlapping testing activities and friction at data interfaces if testing data is uniformly shared between the different stakeholders. With a common test management system, the testing and technical change management could be cross-correlated even down to every single detail. A cooperative test management system would furthermore enable a common understanding of the specifications in each development step and therefore minimizing the testing overhead.

On the other hand, a separated test management in each partition of development always leads to gaps from one development stage to the next or from one party to the next. Data is lost or redundantly created because it cannot or will not be transferred alongside hardware parts to the next stage of development. This is because the testing result data and the related metadata are often confined in private data silos with no authorization of accessing data for different parties.

2.2 Requirements for Cooperative Test Management

We briefly describe the requirements for such a cooperative test management in the following section. Absolutely necessary is a common language for testing scenarios (e.g. like ASAM OpenSCENARIO® for autonomous driving simulation [2]) which must meet the following criteria: it must be clear and unambiguous, simple to use to create new testing scenarios and their respective evaluation routines. It should also be equally well readable for machines and human beings. Not only scenarios may be created but also individual requirements may be added and freely combined. It should be easily adoptable to each party's need and the common language must be open source licenced and may not be patented by one of the parties, otherwise it will not be adopted. Finally, the storage format must also be open source, therefore any proprietary formats shall be excluded. This requirement relates to the data semantics and all metadata of testing data, which must be agreed on. A possible solution to this would be an onthology which would be fully agnostic to the format of storage.

In reality, this is maybe one of the main obstacles on the way towards cooperative test management. Since this would require the parties to openly discuss and agree upon such an open language, to contribute their knowledge in it and eventually agree also to foreign parts inside of it. Also people would be forced to change their practice of testing and data handling and to adopt to something else. A very promising example may be ASAM OpenSCENARIO®, which was developed mainly for simulation purposes and is described on the website as followed [2]: "Maneuver descriptions are an essential part in an effort to test, validate and certify the safety of driver assistance systems and autonomous driving cars. The industry, certification agencies and government authorities jointly work on the definition of maneuver libraries, which can be used to ensure the safe operation of such systems. A publicly developed and vendor-independent standard, such as ASAM OpenSCENARIO, is well suited for this purpose."
Ideally the specifications for a technical part of the full vehicle could be fully written, or at least translated into the common testing language, such that a certified list of results from these tests would be the complete proof of technical fitness.

A promising example of exposing resources for open and cooperative test management is given by openMDM [3]. The information on the website though is not sufficient to evaluate the current maturity of the project and how it can be integrated in cooperative test management.

3 Design Principles of a Blockchain-based Test Management

3.1 Centralized vs. Decentralized Solution

We have no doubt that cooperative test management may also be consistent with a centralized solution. A fully centralized solution would overcome some disadvantages of a disjunctive system, but is subject to the control of one party, which has to be trusted. Such a trusted party could be designed as a supervisory party with the following responsibilities: to create secure central storage with full preservation of political and monetary independence. All parties would massively depend on that central party. This is maybe the reason why this has not happened recently. If only one party would implement such a solution this would lead to trust issues. Or even if that party would impersonate the central role, there would obviously arise immanent transparency problems, since access to these technical systems would always be under the control of that party.

A fully decentralized solution would overcome all disadvantages of a disjunctive system and would not create as many problematic situations as within a centralized system. Blockchain technology is not the only, but the most favourable candidate for creating a technical solution to realize a decentralized system. It may be realized as fully or partly decentralized data storage. The entire scope of the data must not be stored on the blockchain but instead can remain in local databases, whereas results, metadata as well as fingerprints may be stored on the blockchain. The blockchain will serve as trustworthy source of untampered data. In principle, it is more of a communication medium than a genuine database. The distributed storages may react too slowly and are not ready for large amounts of data. But there are new solutions to increase the storage capabilities with the same features like the trustworthiness.

3.2 IOTA Technology

So far we have only referred to the blockchain technology in general, we now need to distinguish between several types of blockchains, without going too much into the technical details. The most common and most well-known blockchain is the Bitcoin alike blockchain. It is a distributed ledger without a central control system. A subversion of this would be the private distributed ledger (for example Hyperledger Sawtooth [4]). Here the advantage is a privately controlled system distributed over several parties. It can be scaled as needed and may serve as a common source of truth. In extreme cases of conflict this would not be the best solution if there are only two or even three parties and they disagree on the version of the ledger: there is no way to finally solve this conflict. From our perspective this is the reason why an open distributed ledger (like e.g. IOTA) should always be the preferred solution. We do not claim that there are not similar plausible solutions, but IOTA is technologically ahead of all others. IOTA did not have the current technological readiness level five years ago, when the automotive industry jointly developed standards like IDS [5]. Now, the IOTA Tangle is a derivative of a blockchain which overcomes mostly all disadvantages and delivers sound solutions to urgent problems (for more details see e.g. [6]):

- First of all IOTA provides feeless transactions on the base layer.
- IOTA Streams addresses the issue of privacy on a public blockchain.
- IOTA comes up with long storage possibilities, to preserve messages on the Tangle.
- IOTA Identities serve as a framework of unchanged identities in trustless networks.
- IOTA second layer addresses possible performance issues and provides Smart Contracts solving the scalability problem.

- Tokenization and NFT's create a framework of endless possibilities of trustworthiness and ownership creation, e.g. data can definitely be owned by one person or institution.
- IOTA Shimmer will create a Tangle platform where current developments can be pushed forward without any risk and extra costs.

In short, IOTA is the most versatile and ready-to-use product in the blockchain crypto market: it aims to become the standard chain for all industrial, social and financial use cases. The IOTA foundation plans the coordicide for the upcoming year, which will boost the project once more. The technological development of IOTA is lead by a foundation and supported by a huge community dedicated to high level applications. The foundation operates the coordinator, which is necessary at the moment to control the validity of the milestones in the Tangle, but this coordinator will become unnecessary and thus will be shut down this year according to the development schedule. IOTA is the only feeless and scaleable solution to meet our requirements.

3.3 Advantages of a Blockchain based Test Management System

Given all stakeholders have agreed on the idea of a cooperative test management to increase efficiency and reduce costs the core concept would consist of the following parts:

- a common testing language (for test bench and full vehicle testing)
- a clear and common understanding of the functional and test specifications along the development history. This may cover the single part up to the full vehicle integration and testing
- an exchange of testing results including the meta data via a common distributed ledger on the basis of a single source of truth. The raw data must not be stored inside the Tangle. In most cases it will be sufficient to provide fingerprints and keys to prove the correctness of data which is stored somewhere in a legacy database.
- an easy to use identification scheme of different roles of the parties, to address the data sovereignity. Each piece of data has its ownership and responsibility.
- a data quality scheme to evaluate the trust status of data. This is another layer of metadata, which enforces a data assessment after production.

The first step of a roadmap towards a fully implemented blockchain solution would be the development of a prototype alongside the concrete development of a part as a proof of concept to show the feasibility of such a solution. In detail this means to create interfaces and solutions which connect all parties to IOTA and handle all the IOTA Identities and IOTA Streams communications. The next step would be the implemention of API interfaces in every development stage as testing benchmark and thus creating a trustable single source of truth. It is worth to mention that creating the human interfaces with a decent UUX development process that thoroughly addresses all the stakeholder's needs is crucial for the success of the project, as this drives forward the acceptance of the software system. To measure the benefit of the test management system, a testing efficiency measure scheme should be implemented, also to prevent testing overhead. Finally, there is a necessity for data quality measures and an incentivized system to provide high quality data. This could be solved in principle by smart contracts. Such smart contracts can also be used to monetize the data in the whole system. If the testing data and testing results could be provided in a standardized way, this would in principle open up a whole new area of business opportunities, self-organized by smart contracts and tokenization of data. This fact and another obvious advantage of a blockchain-based test management is shown in figure 1. When the measurement history is stored inside the IOTA Tangle, the traceability of measurement results is highly increased and can be used for any desired use case.

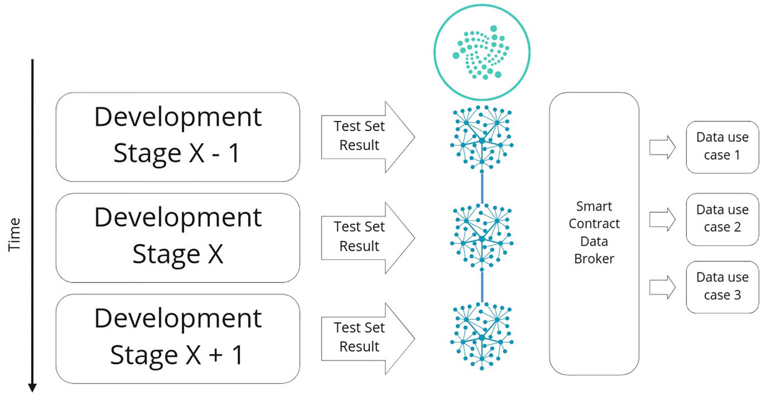

Fig. 1. This figure shows the general setup of a test management system which is interconnected with the IOTA Tangle. The left hand side shows the abstract technical development phases which transfer data of test results in the Tangle by each responsible party. In this way secured, the data can be used in all possible future use cases further on by leveraging smart contract brokers or any other suitable mechanisms. (By using the IOTA logo, the autors do not imply to have affiliation with the IOTA Foundation and the use of the logo does not constitute an endorsement by the IOTA Foundation [7])

4 Relation between Digital Twin and the proposed test management system

Obviously, there is a close relationship between the proposed solution of a cooperative test management on a blockchain and the idea of a digital twin. We may even go one step further and claim that the testing result data and relating metadata is a mandatory part of a digital twin of a prototype of each single technical part. The full potential of such a digital twin can only be unleashed,

if the full testing history will be easily available. The complete testing history during a digital twin lifetime can be stored inside the blockchain.
In the future most of the data would be stored automatically, also on the hardware level. The requirement for that would be a hardware interface from either the testing equipment or of the hardware of the part to be tested directly towards the IOTA Tangle. As soon as this will be available, one could start to prepare the ideal conditions of the digital twin data in the Tangle.

In other fields of technology, progress is already further advanced, like for example for the digital twin of buildings (where BIM is just a starting point) there exist productive models stored in the IOTA Tangle [8]. This shows, that the technology readiness level of the underlying blockchain technology is sufficiently high.

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